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INSTITUTION: University of Central Florida

GRANT TITLE: Final Construction and Operation of a Continuous Far-Infrared Free-Electron Laser for Scientific Applications

REPORTING PERIOD: 1 Nov. 1998 - 31 Dec. 1999

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INSTITUTION: University of Central Florida

OBJECTIVE: (1) To finalize the construction of a compact, high-power, CW FEL for the far-infrared (FIR) region. (2) Utilize the FEL for scientific applications. The expected average laser output power is 600 watts with 10^{-8} fractional spectral homogeneity and better than 20% overall wall power efficiency.

APPROACH: (1) Convert a small 1.7 MeV tandem electrostatic accelerator into a DC electron beam system using electron beam recovery techniques. With low electron beam current (i.e., 200 mA) it will be possible to achieve 99.98% charge beam recovery, which will result in continuous electron beam operation. (2) Develop an 8-mm period compact undulator which will allow FEL operation in the 200-800 μ region. Construct an optical transport system that will channel the laser beam to an existing user laboratory.

<u>ACCOMPLISHMENTS:</u> A layout of the FEL laboratory is shown in figure 1 and a photograph of the FEL apparatus is shown in figure 2. The following is a list of accomplishments (1)Two small, low emittance, 20 kV electron guns have been designed and constructed. (2) A specialized 5 kV electron gun pulser has been constructed. The pulser will be able to operate with variable pulse length (50 nsec- DC). (3) An eight-millimeter period magnetic undulator has been constructed. The dimensions of structure of the undulator are illustrated in figure 3. The measured r.m.s. magnetic field homogeneity is better than 0.1%. A plot of the final field homogeneity is shown in figure 4. This field homogeneity is better than what is required to achieve high electron beam charge recovery. (4) An undulator vacuum chamber has been constructed and tested. To date the chamber pressure is below 10^{-8} torr. The required final chamber pressure is 10^{-9} torr. (5) A remotely controlled hybrid mode FEL resonator is now in operation. The geometry of the resonator is shown in figure 7. (6) Operation of the laser above threshold with a 5 μs pulse length was achieved late in 1997. An

oscilloscope photograph of the signal is shown in figure 8.(7) Nearly full electron beam transmission (>99%) through the magnetic undulator was achieved with the electron beam diagnostics shown in figures 5 and 6(8) All electron beam recovery components are in place. (8) Our present efforts are focussed on implementing maximum electron beam recovery.

SIGNIFICANCE: Device size dominates cost of FELs. Large size devices are intrinsically more expensive to build and operate. It is therefore highly desirable to reduce their size and cost. The UCF CW FEL program resolves these issues by reducing the FEL undulator period. With shorter period undulators, it will be possible to obtain the desired final laser wavelength at reduced electron beam energy and cost of accelerator and ancillary facility. An additional reduction in laboratory facility cost is achieved if the amount of ionizing radiation produced by the FEL can be reduced. This is accomplished with the UCF FEL by means of efficient charge recovery techniques. In addition to reducing cost and levels of ionizing radiation our approach will enable both high average laser power and high levels of laser wall power efficiency.

PUBLICATIONS AND ABSTRACTS:

"First operation of University of Central Florida Free-Electron Laser". P. Tesh, J. Gallagher and L. R. Elias. Ready for submission.

"A short period, highly homogeneous, hybrid magnetic undulator for the University of Central Florida Free-Electron Laser". P. Tesh, J. Gallagher, and L.R. Elias. Ready for submission.

"Electron Acceleration with a Gaussian Laser Beam". L.R. Elias. Ready for submission.

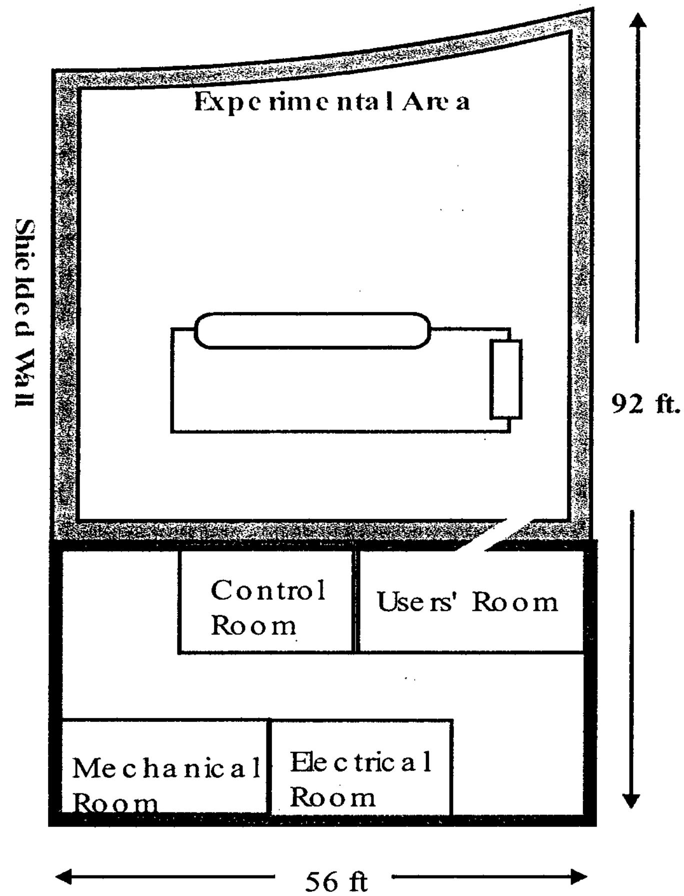


Figure 1. The UCF FEL Laboratory layout.

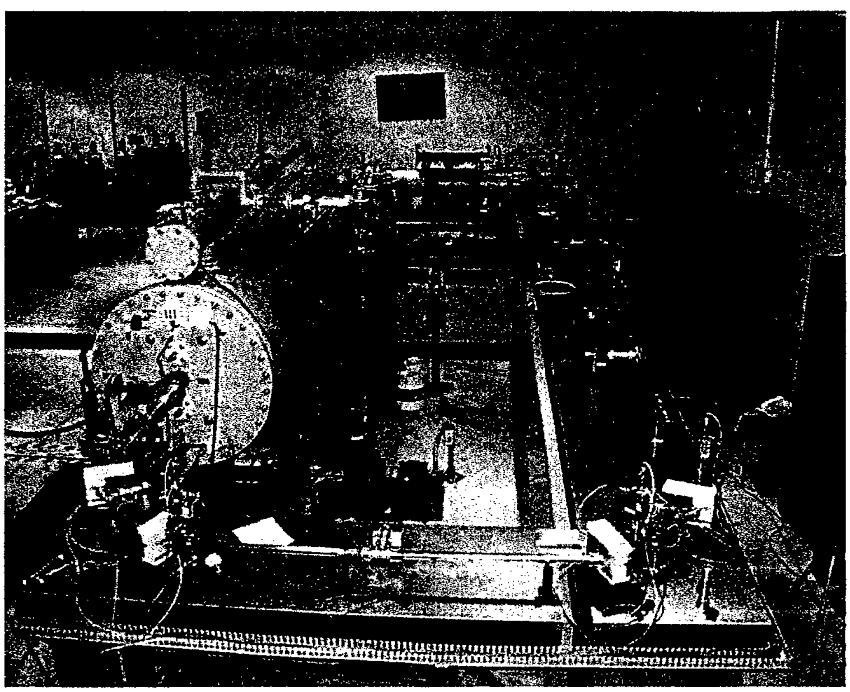


Figure 2. Photograph of the UCF FEL.

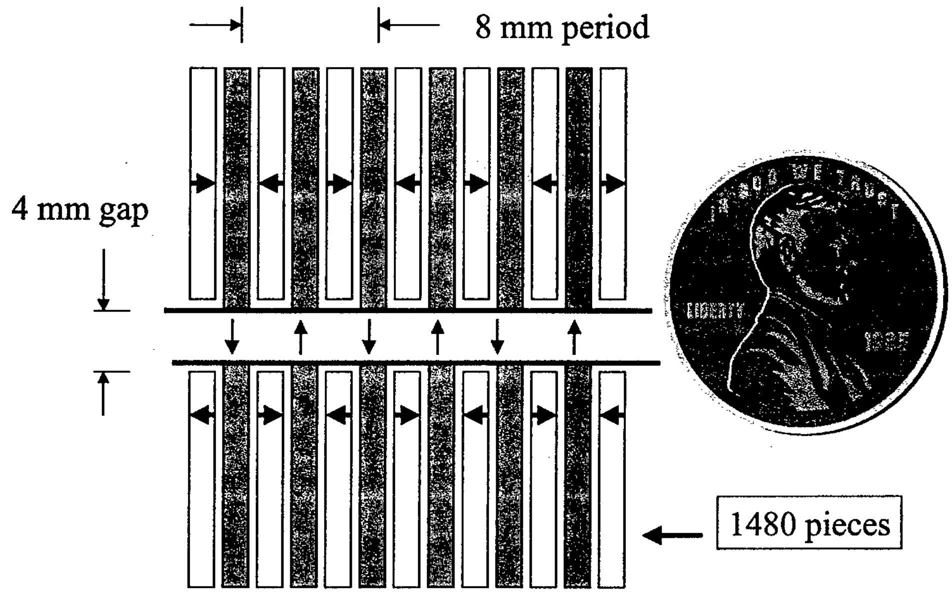


Figure 3. Dimensions of the undulator structure

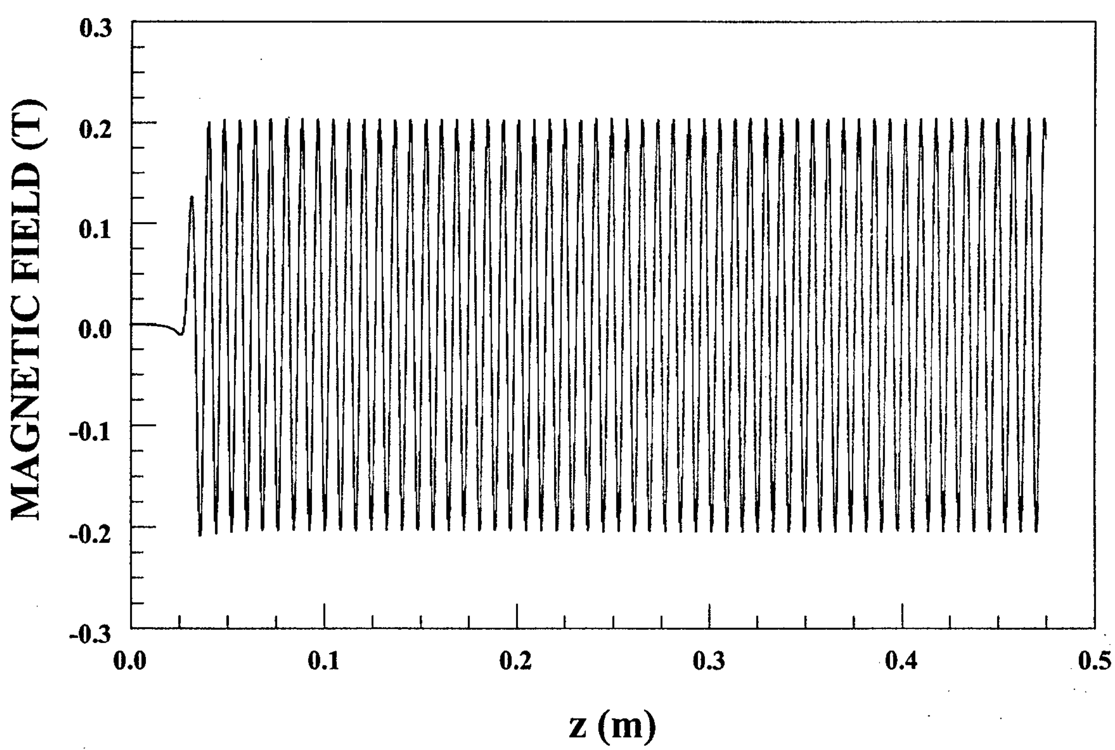


Figure 4. Magnetic field plot of a section of the undulator

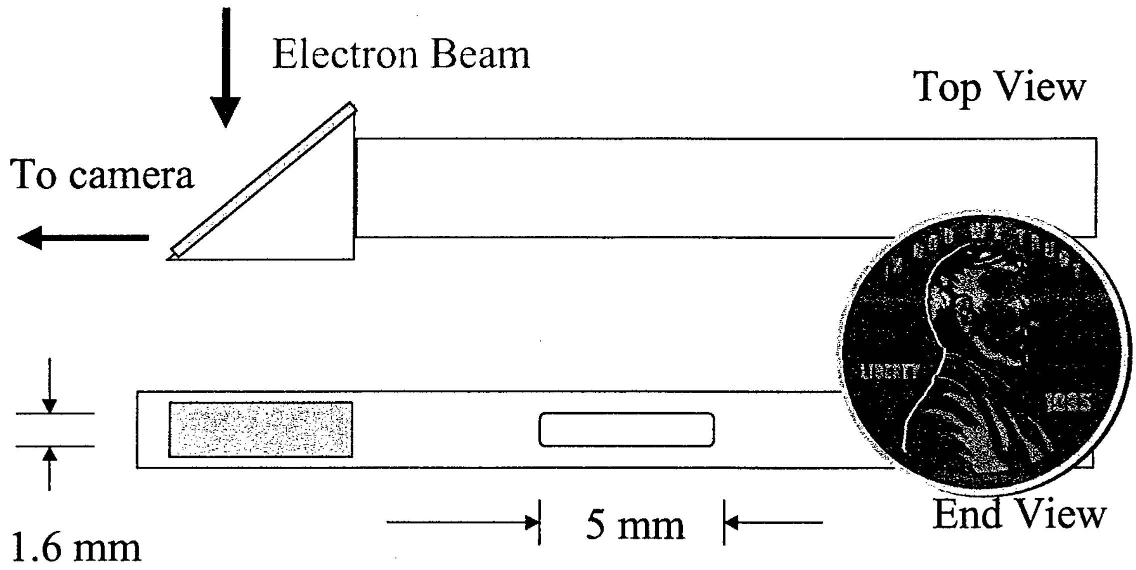


Figure 5. Electron beam diagnostics inside undulator

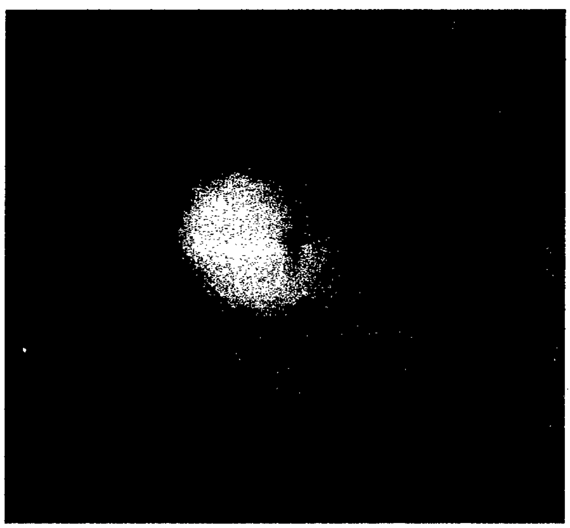


Figure 6. Photograph of the electron beam impinging on a fluorescent screen.

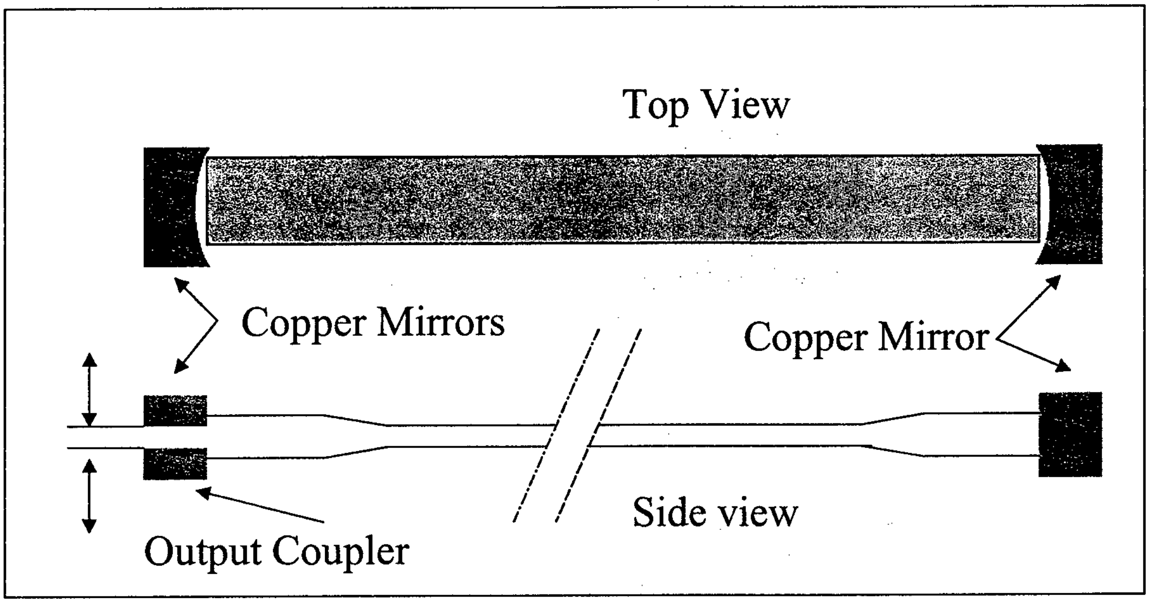
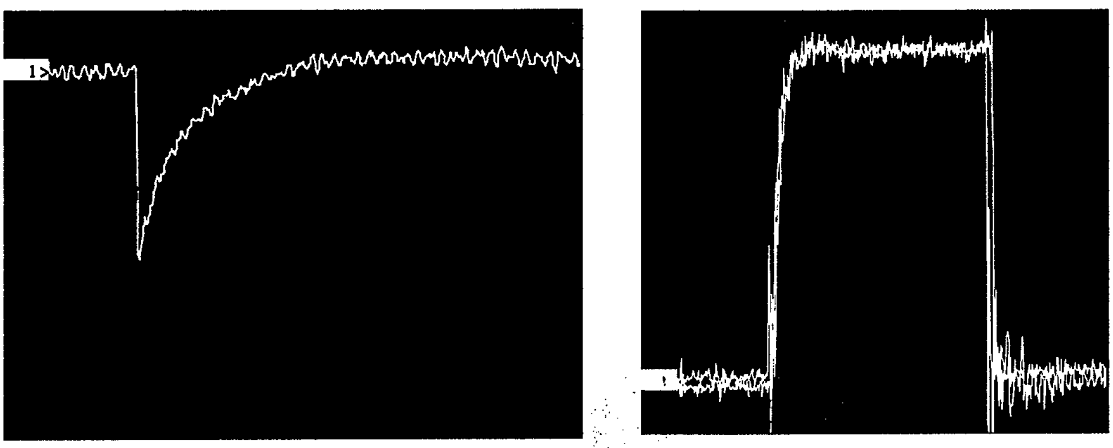


Figure 7. Resonator Geometry



Pyroelectric Detector Signal   Current Monitor Signal

Figure 8. FEL lasing signal detected by a pyroelectric device.

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31 May 2000
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